National Aeronautics and
Space Administration

Office of Biological and Physical Research

USING SPACE TO GET A SOLID FOOTING

PHYSICAL SCIENCES RESEARCH
BIOASTRONAUTICS RESEARCH
FUNDAMENTAL SPACE BIOLOGY
SPACE PRODUCT DEVELOPMENT

Why is it important?

Rip open a vacuum-packed pouch of coffee and you experience a fundamental aspect of soil mechanics or granular materials in general: once pressures are released, the grain assembly moves about freely, almost like a liquid. This can happen to saturated, loose sand in an earthquake or to grains in a silo. During soil liquefaction, a soil-water composite momentarily acts like a viscous liquid as particles lose contact with one another and the material is balanced by the water, allowing buildings to sink and tilt, bridge piers to move, and buried structures to float.

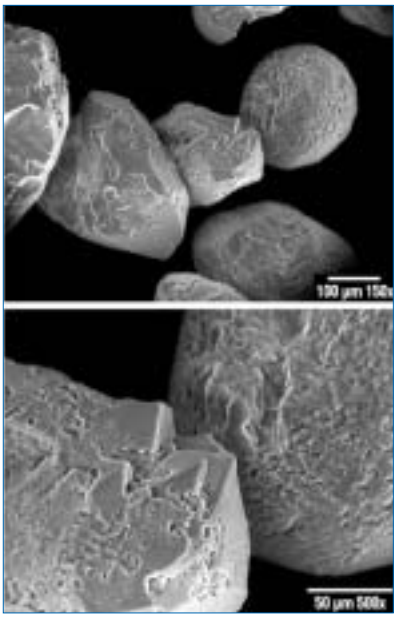
Detailed understanding of this phenomenon is needed to improve techniques for evaluating building sites here on Earth and to improve industrial processes with powdered materials. But on Earth, gravity-induced stresses complicate the analysis and change loads too quickly for detailed study, especially when instabilities occur.

Soil liquefaction during the October 17, 1989, Loma Prieta earthquake made this apartment building in San Francisco's Marina District sink.

What is NASA doing?

A fundamental model of soil behavior in earthquakes is not available in ground-based experiments. However, experiments in space allow low, confining stresses to be maintained for extended measurements. In the first two flights (1996, 1998), the Mechanics of Granular Materials (MGM) experiments showed the following results:

- volume change properties three times larger than predicted,
- very high stiffness properties nearly 10 times greater than predicted, and
- strength properties and instability phenomena quite different from theory.



What look like boulders are sand grains used in the MGM experiments. Countless microscopic faces cause friction until fluid pressure separates the grains and lets them briefly flow like a liquid.

What are the benefits?

Many natural and industrial processes will involve granular materials such as these:

- soil mechanics, geotechnical engineering;
- earthquake engineering;
- mining (open pits, strip mines, tunnels, shafts);
- grain silos, powder feed systems, coal, ash, pharmaceuticals, and fertilizers;
- coastal and offshore engineering;
- wind and water erosion of soil, slope development and decay, volcanic deposition;
- planetary geology; and
- microgravity handling of powders.

What is next?

The MGM-III experiments on STS-107 in 2003 will study earthquake liquefaction behavior. The hardware uses a new specimen reformation technique that allows multiple test runs. NASA is pursuing several investigations of different aspects of granular materials.

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